“BACK TO THE FUTURE”
Smart technologies and the sustainable development goals

J. Carlos Domínguez, Claudia Ortiz Chao and Simone Lucatello

Introduction: from the MDGs to the SDGs
In the year 2000, the UN General Assembly agreed upon a broad international agenda focused on eradicating poverty and tackling some of the most pressing development challenges globally. At the core of this agreement were eight Millennium Development Goals (MDGs). These encompassed concrete targets to be achieved by 2015 (e.g., halving extreme poverty), but more than anything, they were part of an inspirational discourse that attempted to align global efforts for removing some of the main factors hampering the establishment of a “peaceful, prosperous, and just world” (UN General Assembly 2000).

There were remarkable achievements over the following years, including poverty reduction in Asia (particularly China), increasing access to clean water, or HIV/AIDS prevention and treatment worldwide. However, by the time the post-2015 process began in 2010, it was also clear that most efforts would fall short of the original expectations. Progress was concentrated in a few countries, and the international community was still lagging behind in key areas, including environmental sustainability and gender equality (Domínguez and Lucatello 2014: 10–12). Thus, it was necessary to define what would be next: To extend the deadline for achieving the MDGs or to come up with a new agreement, and what kind?

Discussions covered many issues, such as: Should the new agenda be as general as the old one, preserving the inspirational sentiment, providing a common language, and inviting for a broad consensus; or more specific, risking the possibility that many governments did not endorse it and jeopardising the possibilities for a broad consensus? Should the new agenda emphasise goals, despite the limited means that some countries had to achieve them, or vice versa? Should sensitive subjects, such as peace and international security or human rights and governance, be included, or not? Should indicators and targets be defined by each government or by the international community beforehand?

Unlike the first agenda, the SDGs were the result of a multi-layered process involving international agencies, traditional and emerging donors, civil society, and academia, as well as individual countries and country coalitions (e.g., G20, G77, BRICS, or G7+). The process also overlapped and nourished other forums such as Río +20 and climate change negotiations. If the MDGs had been narrowly discussed and agreed upon by heads of states and governments, the SDGs would result from long and extensive deliberations, studies, and massive efforts, including...
public consultations in many countries and the involvement of a broad collection of stakeholders and working groups, such as thematic task forces or the UN Secretary-General’s High-Level Panel of eminent persons, among others.

Agenda 2030 and the respective Sustainable Development Goals (SDGs) stemmed from these long and strenuous debates. And thus, in comparison to the MDGs, the SDGs are designed with an all-encompassing, maximalist view, trying to tackle development challenges with a more comprehensive approach. It encompasses 17 goals, 169 unique indicators, and 231 targets.

And yet, despite the scope and nuances of the SDGs, there was a noticeable absence during the post-2015 debates: the opportunities and challenges that digitalisation and smart technologies (STs) might create for achieving Agenda 2030. While the early MDGs include a short mention on the need to “make available the benefits of new technologies, especially information and communications” (Target 8.F), the SDGs increased the role of technological adoption but remained mostly within a similar “have vs have not” approach.

The SDGs include the proportion of “youth and young adults with information and communications technology (ICT), skills, and kind of skills” (Indicator 4.4.1), and the proportion of schools with access to internet (Indicator 4.a.1), under the umbrella of Goal 4 (quality education). Other indicators include the number of scholarships available for developing countries in a number of professional areas, including ICT (also as part of Goal 4); “enhancing the use of enabling technology, in particular information and communication technology, to promote the empowerment of women” (Goal 5; Indicator 5.b); quick references to technology upgrading in general (not necessarily digital or smart), particularly in Goals 6, 7, 8, 9, 13, and 14, and a subsection of Goal 17 (global partnership for sustainable development), comprising three short paragraphs, mainly focused on knowledge sharing and technological capacity building, with an emphasis on Least Developed Countries (LDCs).

The lack of a more systematic and integral approach to the impact of digital technologies is striking in the case of both the MDGs and the SDGs, but particularly in the latter, if we consider that the digital revolution had been happening for two decades by the time Agenda 2030 was approved. The World Wide Web was launched in the early 1990s, the euphoria around the dot-coms occurred between 1995 and 2002, and many visionary works suggesting how digital and STs would eventually change our daily lives had already been published in the late 1990s and early 2000s (Castells 1995, 2001a, 2001b, 2002; Mitchell 2000; Negroponte 1995, just to cite a few examples).

The project One Laptop per Child (OLPC) was launched by academics from the Massachusetts Institute of Technology (MIT) in 2005, but it was mainly promoted by private companies and foundations interested in fostering the education and knowledge of children through information. Development institutions and professionals hardly endorsed the initiative, despite the fact that a few heads of state had mentioned the possibility of a digital divide already in the late 1990s (Gore 1998).

The World Bank did not issue a report on digitalisation and development until 2016, and the United Nations Development Programme (UNDP) did not launch a comprehensive digital transformation strategy until 2019. Other instances include the TWI 2050 initiative, where digitalisation constitutes one of six major societal transformations impacting the overarching goal of sustainability (its first report published in 2018) and, more recently, the Technology Executive Committee (TEC) at the United Nations Framework Convention for Climate Change (UNFCCC).

How is it possible that aid and cooperation agencies, international financial institutions, academics, and development consultants remained relatively oblivious to the debate on digitalisation and STs for so long? What are the implications of such omission, where are we now, and where is the debate likely to head in the future?
There are three likely reasons why development agendas have lagged behind the technological debate. First, the Millennium Declaration was drafted with a focus on tackling the needs of the most vulnerable, fighting extreme poverty, and helping developing countries and economies in transition in an increasingly globalised world (UN 2000). The belief that digital technologies (particularly the internet) was a kind of luxury and that basic human development should be guaranteed first (education, health, nutrition, income) likely permeated the philosophy of development professionals in those days. Second, the full potential of STs (the popularisation of mobile apps, AI, big data, machine learning, smart cities, blockchain, among other innovations) had not been properly revealed beyond a small clique of technical experts. And, third, many innovations were (and continue to be) market-driven rather than development-driven (Domínguez 2018).

Looking at these factors from a historical perspective is useful to understand where and why the SDGs stand regarding technology in general and STs in specific. As the international agenda moved from an emphasis on the poorest and least developed societies (MDGs) to include vulnerable populations in developed and industrialised countries, as well as encompassing a broader and more comprehensive set of goals and indicators (SDGs), the role of technology also increased slightly.

Conversely, as technological change has accelerated greatly in the last ten years, its potential to tackle development challenges has also become more evident and development professionals tend to be more enthusiastic regarding these possibilities. In fact, one of the main challenges in the near future lies in avoiding a complete swing from the argument that basic needs should be tackled first, before technology is adopted, towards the argument that technology can be introduced first and solve everything. The development community needs to find a healthy middle point. It needs to go “back to the future” and imagine how STs could shape development in the years to come, but this should not be done blindfolded. In catching up with technological innovations and their impacts on development processes, it is crucial to weigh both threats and opportunities. The following sections offer a few examples.

**Can STs help with reducing poverty and eradicating hunger while remaining oblivious to structural inequalities?**

The zeal to employ STs as means to achieve the SDGs is reflected in many reports and official documents by international development agencies (FAO 2018; UNDP 2019; World Bank 2016). In one way or another, these reports also adopt different definitions of the “have” vs “have not” problem, as if solving the access to the digital world and the availability of STs constituted the main societal challenge. National policies in many countries have also been designed with such a narrow approach in mind, taking indicators such as the population with access to broadband connections, the number of schools with internet connections, the number of small businesses that use STs, or the number of public services online as key policy indicators. The so-called emerging powers, such as Brazil, India, or Mexico, are a few examples of this trend. No doubt these indicators are necessary to measure one side of the technological equation (access to and availability of infrastructure), but they are not enough.

Thus, from being relatively absent at the dawn of the development agenda, STs are often referred to as a kind of panacea, disregarding the possibility of negative scenarios. These include the possibility that smart devices and apps might not be enough for solving development problems, that the adoption and introduction of STs may actually have side-effects and negative impacts over the long term, or that such strategy might hugely increase inequalities domestically and internationally, leaving the poorest and the most vulnerable behind. Over-optimistic views
are mostly held by industry players, but development professionals and academics may also fall into this trap. In fact, in analysing side-effects and negative impacts, these latter often lag behind discussions in the areas of internet and media studies, technology assessment (TA), or sociology of science and technology in general.

Take, for example, the case of the internet. Scholars within sociology and internet studies have researched different aspects of the digital divide in the last 20 years, coming up with new perspectives “on the rise and persistence of digital inequalities” (Ragnedda and Muschert 2018: 2). A bird’s-eye view of this research suggests, both theoretically and empirically (Ragnedda and Ruig 2018; van Deursen and van Dijk 2015), that digital divides can’t be pinned down satisfactorily; that there are structural variables, determined first in the offline world (for example, income and education), which greatly limit the potential that online activities have to translate into offline benefits; and, therefore, that digitalisation and STs can actually increase inequality significantly if they are not accompanied by the right policies. A scenario where digitalisation systematically increases inequality inside societies and between countries could inhibit the progress in many indicators that are part of SDGs 1 to 7 (i.e., those related to social outcomes).

The internet is perhaps one of the most widespread and studied technologies in the last two decades, but the same conclusions seem applicable to other STs. For example, as the research published by Vinuesa et al. (2020: 2) suggests, the application of AI has positive prospects as an enabler of different SDGs, such as 1 (no poverty), 4 (quality education), 6 (clean water and sanitation), 7 (affordable clean energy), and 11 (sustainable cities and communities), by supporting the provision of food, education, water, and energy services more efficiently and by contributing to save resources that could – hypothetically – be employed to tackle other social and economic challenges.

And yet, these authors also warn that AI could also trigger deeper inequalities (SDG 10), inhibiting or cancelling out some of these positive achievements in other areas. Some issues include the possibility that AI innovations are often market–driven and respond to market demands, which are located mainly in rich countries or driven by socioeconomically privileged minorities in low and middle-income countries. Moreover, given some features of AI (data analysis, pattern recognition, prediction, interactive communication), these technologies are highly sensitive to specific sociocultural backgrounds. Thus, it is not clear whether legal and ethical dilemmas regarding privacy, surveillance, bias and discrimination, or social control could be exacerbated in LDCs or simply hinder the adoption and usefulness of these technologies.

In the first case (exacerbated dilemmas), the misuse of AI could have an impact on SDG 16 (peace, justice, and strong institutions) given the threat to human rights and the social tensions which could arise from the outcomes mentioned earlier. In the second case (limited adoption), there is a risk that societies with a stronger technological aversion exacerbate their rejection towards development solutions that rely heavily on the use of STs in general. Overall, this could contribute to a persistent gap between those who employ AI to produce socioeconomically meaningful outcomes and those who are not in a position to take advantage of it.

AI, combined with other STs, may increase inequality mainly through its impacts on the labour market. Given the trends towards automation in different economic sectors (mainly services and commerce, but increasingly more in industry), it is likely that a large share of low-skilled jobs will be displaced, whereas some middle-skilled workers might suffer from re-taylorisation and a few high-skilled jobs will be better paid.

These trends will vary across different countries, depending on historical backgrounds, sociocultural attitudes towards technology, and socioeconomic inequalities, as well as the kind of policy interventions that are put in place by their respective governments. For example, it is unclear whether a high-income, industrialised country, like Germany, which has adopted
a precautionary principle with regard to the adoption of AI, will enjoy higher technological yields in the long term in comparison to a low middle-income country, like India, which favours a much more aggressive adoption of AI. Despite enjoying a competitive advantage, based on a solid and buoyant software industry, the latter country exhibits persistent inequalities (particularly between urban and rural population) and a gigantic surplus of unskilled labour.

It is likely that the comparative impact on SDGs 8 (decent work and economic growth), 9 (industry, innovation, and infrastructure), and 10 (reduced inequalities) will depend on the mix of government policies, together with the active participation of other stakeholders. For example, Germany has put a lot of emphasis on working together with the labour unions on retraining, skill development, and collective bargaining as ways to balance between the benefits of technological innovation and the need for compensatory policies. Countries like Brazil or Mexico have not paid enough attention to the importance of a strong safety net, and countries like India have betted on the possibility that speedy innovation will bring about long-term efficiency gains and yield enough economic surplus to be transferred to the poorest and most vulnerable.

Research on the comparative impacts of AI between countries with different levels of income per capita, or between countries with similar socioeconomic development but different historical and sociocultural backgrounds, will be very useful in the near future. Many impacts are unlikely to become fully visible before Agenda 2030 reaches its deadline, but many others might already be available to nourish research on the comparative politics and policies of technological adoption, as well as on its impacts and implications for the SDGs.

The research on digital divides and the research on AI, automation, and job displacement both suggest that there are structural inequalities that need to be tackled in parallel to the dynamics of technological adoption. There are some basic structural requirements that should be met to boost the impact of STs on the SDGs. The availability of good-quality primary and secondary education, as well as vocational training, are two examples. Both dimensions, considered within SDGs 4 (quality education) and 8 (clean water and sanitation), might be enhanced through STs, but these will not be enough on their own.

The paradox is that those individuals and groups with higher levels of education seem to be better positioned to take advantage of STs to educate themselves further; those better trained are the ones that have better jobs and, therefore, those who have more time and flexibility to keep training themselves; and those with higher status and/or income levels are those that are better placed to accumulate even more economic capital thanks to their usage of digital technologies (Calderón Gómez 2020; Van Deursen and Helsper 2015; Zillien and Hargittai 2009).

There is no doubt that STs can work as enablers of development processes and have significant contributions to Agenda 2030. However, STs are likely to increase inequality and have uneven impacts on different economic, social, and political indicators that are covered by the SDGs, if basic aspects of these SDGs themselves are not tackled at the same time.

The impacts that technological change, innovation, and skills have on efficiency, productivity gains, competitiveness, economic growth, market concentration, and/or wage dispersion have been studied extensively by development economists. This includes research on the role of technological change in general (Lall 2001), as well as more specific studies, focused on digitalisation, automation, and other STs (Allen 2017; Ferschli et al. 2020; World Bank 2016). And yet, more research is needed to understand the different causal mechanisms linking development (broadly speaking, beyond market outcomes) and STs adoption.

The impacts on Goal 2 (zero hunger) are illustrative. International agencies, such as the FAO (2018) and World Bank (2016) have stressed the potential impact of STs such as AI, machine learning, data science, IoT, remote sensing, and blockchain on reduced information
and transaction costs, improved crop management, and access to financial services. The impact of these technologies is already patent in many developed countries but, apart from a few pilot projects and case studies, developing and LDCs are still lagging behind.

One example in a low-income country is the case of the Community Knowledge Workers initiative, supported by the Grameen Foundation (2018), which aims to provide advisory services and to build “a network of community agents in Uganda who act as intermediaries between smallholders and smartphone app content developers” (FAO 2020: 10). An example in an upper middle-income country is “Smart Campo” in Brazil (and Paraguay), a platform that has been “developed to help farmers in Brazil and Paraguay optimise field management by incorporating weather and climate information into the decision-making process” (Smart Campo 2020).

And yet, there are longstanding structural inequalities in the rural sector of most of the developing world that cannot be underestimated. Economic dualism, for instance, is a persistent feature which can be broadly described as having two agricultural sectors in one: on the one hand, around 20% of production units that are relatively large, very competitive, market-oriented, risk takers, and technology-friendly, in charge of 80% of agricultural production; and on the other hand, 80% of small-holders, not very efficient, risk averse, not very enthusiastic of technological innovations, in charge of 20% of agricultural production, and mostly focused on self-consumption (Ghatak and Ingersent 1984: 4–25).

The numbers and the proportions might have changed slightly since development economists, such as William Arthur Lewis, first talked about economic dualism (Lewis 1954); they might vary from country to country; and there might be new shades in between these two extremes, but there is little doubt that there is a persistent gap between large-scale units that are linked to global agroindustry chains and a vast universe of very poor and vulnerable small-holders. These structural conditions pose a significant challenge for the adoption of STs intended to enable SDG 2 without increasing inequalities in general, simply for the fact that large firms, which are already productive and competitive, are more inclined to adopt innovations in comparison to small-holders, which tend to be poor and vulnerable.

Moreover, regions such as Latin America and especially Africa have relatively young populations. This is double-edged if we consider both the economic and the sociocultural implications. On the one hand, this demographic group might be more willing to adopt and use STs. However, on the other hand, the access to digital technologies, such as the internet, can also feed new models and social expectations that may (apparently) be satisfied when the youth migrate from rural to urban areas. Thus, the challenge lies in promoting STs that are meaningful in multiple ways: that increase economic efficiency but also take into account demographic and sociocultural factors.

There are a few examples of how the poor in both rural and urban areas have benefited from STs. One case is increasing financial inclusion thanks to the widespread use of mobiles and financial apps. However, these benefits should not be taken for granted. There is ample scope for more research on the interplay between the above-mentioned dimensions in specific local contexts and the ways that the impact of STs on SDGs 1 and 2 are maximised.

Can STs help with achieving healthy lives while tackling the challenges of surveillance and social control?

Income inequality is often correlated with geographical location and has an impact on different indicators of well-being and sustainable development, including the ability to enjoy healthy lives (SDG 3). Not surprisingly, the levels of poverty and inequality worldwide are also reflected
in the fact that, in 2017, less than half of the global population was covered by essential health services (United Nations 2021).

Eligibility to public or private medical services or access to cultural or social amenities are two areas that enhance human development. However, low income is often correlated with living in segregated areas, a condition that limits citizens’ ability to reach goods, places, facilities, and services that are necessary to promote different aspects of well-being. In this respect, STs offer opportunities to bridge physical distance and enhance indicators such as the coverage of essential health services (Indicator 3.8.1) or the number of people covered by health insurance or a public health system per 1,000 population (Indicator 3.8.2), contributing to achieving the target of universal health coverage.

Living in segregated areas means not only that basic health services are far away, but that time invested in reaching them also limits the spare time available for cultural and social activities, decreasing the ability of citizens to enjoy healthy and culturally meaningful lives. Even large urban areas, with thriving and consolidated economies, and with above-average provision of health services and facilities, exhibit unequal access.

A recent paper on mobility highlights that access to jobs, services, and people is key to a city’s economic vitality and quality of life. However, the trend seems to be a decline in accessibility in the global South, showing that up to half of urban population experiences restricted access, leading to travel burdens or exclusion from opportunities. The most affected are low- to medium-income groups in suburbs and peripheral settlements, as well as low-income groups in other areas of the city (Venter et al. 2019).

In Mexico City, for example, someone in an upper-income neighbourhood will have 28 times more access to jobs within a 30-minute trip by public transport, than someone living in a lower-class neighbourhood. The same pattern persists for other goods and services, such as medical attention, education, food provision, or culture and entertainment (WRI 2019). The outlook gets grimmer if mere access is also pondered according to quality of provision.

Moreover, structural inequalities can easily worsen in the context of difficult global conjunctures. Due to the COVID-19 pandemic, progress in the provision of health services has been jeopardised. Achievements in the last few years could be reversed or, at best, temporarily disrupted. How can governments tackle these inequalities and deal with these challenges? Could STs offer innovative ways to bring medical services and attention closer to people? The COVID-19 health crisis is itself illustrative of both costs and benefits, threats and opportunities.

A comparison between political measures carried out by governments around the world to face the effects of the pandemic suggests four kinds of measures: public health, digital surveillance, social distance, and repression (Ojeda 2020). According to this analysis, countries like South Korea and Taiwan showed the smartest approach, indeed strongly guided by data and technology, coupled by an early reaction to the crisis. Health interventions included key elements, such as the massive application of tests, the development of new test techniques, and the development of smart apps to retrace the movement of infected people and to make public health services more accessible. These latter were effective thanks to the collaboration between government and civil society to generate data massively.

Countries like China were also very effective in flattening the COVID-19 curve, and STs were also strategic. Medical technology included test development, heat sensors, and industrial technology to adapt innovations to medical needs. The use of advanced technology for digital monitoring and surveillance was remarkable, but it also encompassed a strong state presence and citizen control. Some features included: monitoring of people’s smartphones with real-time GPS, accessing personal data massively, using millions of cameras for face-recognition, obligatory reporting of body temperature, and employing apps to warn citizens about proximity to
infected patients. Social distance and confinement became mandatory, with enforcement measures that were borderline repressive: the instalment of permanent control posts, the tracking of times and frequency that citizens were going in and out of their homes, as well as restrictions of movement between provinces (Ko 2020; Zhong and Mozur 2020).

Scholars have warned about the dangers of this extreme surveillance developing into a deeper level of 24/7 biometric surveillance or “under-the-skin surveillance” (Harari 2020; Schneider 2020; and Zuboff 2019). They have also warned about the possibility that temporary measures outlast emergencies, as there is always a new emergency hanging out on the horizon (a second wave or a different epidemic or pandemic or other).

Thus, while digitalisation and STs offer enormous opportunities for improvements in the health sector and for achieving indicators within SDG 3, they also pose significant societal threats and challenges that could undermine or inhibit achievements within SDG 16 due to their impact on privacy and human rights (the protection of fundamental freedoms, in accordance with national legislation and international agreements, is part of this SDG). Smart technologies may underpin the development of health treatments in record times and contribute to monitor populations and contain the spread of diseases; to improve medical diagnoses; and/or to deploy massive immunisation efforts more efficiently (Berkley 2017). But the fact that health apps rely heavily on AI and big data analytics means they can easily become threats in “regions where ethical scrutiny, transparency, and democratic control are lacking” (Vinuesa et al. 2020: 3).

The contrast between opportunities and threats suggests that, while STs are helpful in this kind of crisis, their net impacts will depend on specific political contexts and governance models. STs can either be used vertically, feeding into strong surveillance and control models; or more horizontally, through social participation at different levels, together with long-term strategies that do not jeopardise basic citizen rights and liberties. Comparative research on the relation between STs, political governance, sociocultural contexts, and their impact on diverse outcomes in the health sector will prove useful to identify cross-case lessons and design better policies to enhance this area of Agenda 2030.

It should also be noticed that, beyond specific health crises, the long-term usefulness of STs to tackle health challenges depends on other structural factors that were described previously, when discussing SDGs 1 and 2 (no poverty and zero hunger). STs cannot always compensate for the lack of basic medical materials, deficient infrastructure, untrained doctors, or patients’ limited education, which is often the case in developing countries and LDCs.

Similar to the case of other SDGs, STs hardly ever offer a magic bullet to solve all deficiencies and all inequalities in the health sector. Without tackling educational gaps or properly increasing the availability of smartphones and other devices, STs are likely to benefit privileged populations and to leave the poorest and most vulnerable behind. Without solving proper infrastructure deficiencies, STs in the health sector might reinforce operational bottlenecks, rather than solving them. Without designing adequate user interfaces, STs are likely to reinforce the exclusion of vulnerable populations that need quality healthcare the most, such as the elderly or citizens with disabilities. In this respect, the research that has been conducted on the provision of different e-government services (Park and Humphry 2019; Ranchordás 2021; Yates et al. 2013) might also be applied to healthcare.

Promoting widespread data and algorithm literacy among the general population is important to maximise the positive impact of STs on SDGs; they are necessary to prevent negative impacts on citizens’ privacy and better governance models. In the case of health and medical care, they are particularly important if we consider that the access to massive biometric data constitutes an essential input for the efficiency of STs.
Can STs help to build sustainable cities and communities without falling into the trap of technological fixations?

As we live in an increasingly urban world, the impact of STs on SDGs cannot be fully grasped without understanding the particular dynamics of large and medium cities. Already in 2018, the UN reported that 55% of the world’s population lived in urban areas, a proportion expected to increase to 68% by 2050 (UN 2018). Cities also concentrate economic activity, contributing about 60% of global GDP. However, they also account for about 70% of global carbon emissions and over 60% of resource use (UN 2021).

In this respect, the development of new tools and technologies has certainly enabled cities to improve some of their biggest challenges. Efficient transport and mobility, for example, are essential to consolidate more sustainable cities. Both are considered as part of SDG 11 (sustainable cities and communities) and constitute key areas that need to be tackled if inclusive economic growth is to be achieved (SDG 8).

Although one might immediately think of high-speed trains and self-driving vehicles, which can certainly contribute to some extent, integrated transit systems are at the centre of expanding the coverage of public transport networks. This in turn can make public alternatives more convenient and flexible vis-à-vis the extensive use of private cars, contributing to SDG 13 (climate action). If we consider that a citizen of New Delhi or Mexico City might spend around 200 hours a year in traffic, this means that more efficient transport can also contribute to SDG 3 by increasing spare time and reducing unnecessary psychological stress.

The International Transport Forum (Kager and Harms 2017) talks about seamless integration of all modes of transport (bus, bus rapid transit systems, light rail, metro and rail systems, as well as walking and cycling) as the key point and the main challenge to achieve better mobility. This includes proper intermodal infrastructure but also smart integrated ticketing systems and information systems (IS) that inform users about availability, modes, and route efficiency in real time, preferably through personalised interfaces and apps. This is the case of cities such as London, Berlin, or Vienna, where IS also include information on access for users with special requirements such as stations with elevators, ramps, tactile guidance for the visually impaired, etc.

The inclusion of cycling as part of a multimodal integrated scheme can also extend the reach of public transport networks. In this respect, digitalisation has played an important role in increasing bike use thanks to bike-share systems, both dock-based and dock-free, as these are often linked to mobile applications. Shared electric scooters work the same way. Other cities, like San Francisco, have launched programs to improve parking availability and efficiency: the SFpark Pilot Program uses wireless sensors to monitor parking-space occupancy in real time, distributing this information among drivers so they can find free spaces faster, reducing the amount of time vehicles circle and, hence, congestion and gas emissions (www.sfmta.com). The city then uses this information to adjust parking prices periodically to encourage more parking in underused areas and control it in areas of high demand.

STs have also helped to increase and improve communication, as well as the involvement of society in a series of urban processes such as the so-called planning support systems (PSS) which have existed since the 1980s. These are digital tools, notably geographical information systems (GIS), that support planning processes of different types and at different stages (Batty 2007; Geertman 2006). Examples of PSS vary widely in complexity, from interactive viewers to digital platforms capable of modelling geospatial alternatives and scenarios based on variables and parameters defined by users, but all of them contribute in different measures to SDG 16 (peace, justice, and strong institutions) by enhancing indicators on democracy and political participation.
Technological advances such as open-source GIS, big data, cloud computing, and the growing capacity of web navigators with a reduction in costs have pushed the development of PSS in recent years. In terms of societal involvement, GIS- and web-based tools have allowed for a faster, broader, more democratic, and more significant access to and use of data. These in turn have also supported the work of different initiatives, including observatories, whether academic, governmental or citizen in origin, and thus also contribute to SDG 16.

Clearly, the proliferation of individual mobile devices and sensors of different kinds has leapfrogged the production of data in cities while also making it extremely detailed, both in time-scale and spatial resolution (Batty 2012). In this respect, big data could potentially be used to improve cities and make them more efficient. The big tech giants are already mining this data for different purposes: marketing, advertising, entertainment. However, this raises the following question: How can we integrate big data and technological innovations that are mainly market-driven with traditional data on planning and design, in ways that improve the management of cities, making them safer, more equitable, and, overall, better and more liveable?

The answer is that STs constitute only one of many ingredients necessary to achieve better city management and administration models. Advances and data will only be useful if used smartly, in the context of interconnected and aligned strategies, with effective coordination, both vertical and horizontal. Linear and fragmentary urban policies have long been shown to fail, even if they are supported by technological innovations. As stated by Batty already in 2012, “The key is no longer technological, as ever it is organisational” (192).

Can STs contribute to climate action and to achieving more environmentally sustainable ways of living without falling into the trap of the Promethean Myth?

Climate change is the most important threat to global welfare of our times. Increasing temperatures due to greenhouse gas emissions (GHG) are stressing ecological and social systems, jeopardising their long-term sustainability like never before. In this respect, in the same year that Agenda 2030 was approved, the international community also signed the Paris Agreement (PA), which commits all signatory countries to keeping global warming to “below 2° C” and, if possible, below 1.5° C above pre-industrial levels (IPCC 2018; United Nations 2015; Goal 13 of the SDGs). Achieving these targets will require fundamental changes to our transportation, agricultural, building, and energy sectors. Can digitalisation and STs offer significant opportunities to enhance both mitigation and adaptation strategies? What are the opportunities and threats, benefits and costs?

Climate science is already relying heavily on massive data gathering and AI, which is applied to improve the monitoring of GHGs and their sources. As stated by Vinuesa et al. (2020: 4), “benefits from A.I. could be derived by the possibility of analysing large-scale interconnected databases to develop joint actions aimed at preserving the environment”. AI is also used to downscale climate effects in particular areas of the world as well as to improve weather forecasts or understand different variables such as temperature and humidity, and their interaction with GHGs. At the same time, the number of satellites launched into space over the past decade has increased exponentially, so that AI and satellite imaging can now be used to monitor and analyse the state of forests and oceans (Goals 14 and 15).

Another clear application of digital technologies lies in their potential to improve climate modelling and predictions. For example, meteorology and earth science have largely benefited from machine learning and other STs to improve accuracy and predictability of natural hazards such as hurricanes and tropical storms. This can in turn have positive impacts on SDG 2
because farmers in rural areas could benefit greatly from these applications, reducing risk and improving crop management (as discussed earlier). Some examples include a closer cooperation between United Nations Food and Agriculture Organisation (FAO) and the World Meteorological Association (WMO); the platform SERVIR, developed together by NADA and USAID; or AfricaAdapt in Senegal, all of which aim at offering better meteorological information to help poor farmers face the risks of climate change (FAO 2018: 11).

AI, deep learning, robotics, big data, IoT, and automated decision-making systems, among other STs, are increasingly recognised as important tools for societal transformation (Graglia et al. 2018), and even though the interrelations between climate change action and digital technologies has not yet been fully explored, it is likely that these latter will work not as mere “instruments” for solving sustainability challenges, but rather as fundamental, disruptive, and multi-scalar drivers of change (TWI2050 2018). STs may have substantial positive impacts by supporting the decarbonisation of society in areas such as energy, transportation (see discussion earlier on sustainable cities; Stain 2020), agriculture (see discussion earlier on SDGs 1 and 2), and buildings. It can also help to monitor global environmental indicators such as biodiversity loss (SDGs 14 and 15).

And yet, digitalisation and STs can also be double-edged. Digitalisation narratives frequently emphasise the benefits and enabling potential of digital technologies to solve environmental problems, but they often remain oblivious to their negative impacts. One example is the increasing digital carbon footprint, given the fact that data centres and computing power consume increasing amounts of energy. Another example is the extraction and depletion of valuable resources such as cobalt, palladium, tantalum, silver, gold, indium, copper, lithium, and magnesium, as well as the growing volume of electronic waste which needs to be collected, recycled, or disposed of.

To date, based on the available literature, it remains unclear whether the positive indirect environmental impacts can outweigh the negative direct ones (or the other way round) given the interplay between many economic, political, social, and cultural factors. Further and more detailed analysis of the trade-offs between positive and negative effects will be needed in the near future. For example, according to a pessimistic scenario, GHG emissions may not be reduced overtime but increased instead. Whether this or more moderate scenarios are likely to materialise in the long term, it is clear that STs will not solve climate change and environmental problems on their own.

To believe so would be to fall into the trap of the Promethean Myth (Dryzek 1997); that is, the wrong belief that “technology can be used to overcome any problem facing humanity, including those related to climate change and the environment in general” (Domínguez and Karaisl 2012: 103). For STs to have lasting impacts on SDGs 13, 14, and 15, it is also necessary to find ways to change broader production and consumption patterns (SDG 7 and 12).

At the same time, the extraction of valuable resources used to manufacture batteries and digital devices is a phenomenon that is already causing serious environmental impacts (such as soil acidification, human toxicity, and groundwater pollution) and human rights violations locally (including the forced displacement of populations and the murdering of environmental activists), in both Africa and Latin America. It is not clear whether STs, together with satellite and drone surveillance, are also contributing to increasing the efficiency of large corporations to screen, to localise, to image, and to target the extraction and commercialisation of natural resources in areas that were previously unexplored and unexploited, but the impacts of these market-oriented dynamics should also be studied with more detail.

These situations seriously risk the progress in other aspects of Agenda 2030, such as SDG 16 (peaceful and inclusive societies for sustainable development) and other indicators and targets of
SDGs 14 (life below water) and 15 (life on land). All these aspects need to be examined, both to understand the large-scale impact of current technological trends and to find ways to gear innovation towards more comprehensive development solutions.

Can STs contribute to achieve SDGs that have positive impacts across the whole Agenda 2030, while minimising negative “side effects”?

One of the most significant challenges (and sources of criticism) regarding the application of Agenda 2030 is that the 17 goals, together with 169 indicators and 231 targets, are closely intermingled and co-determined by each other. Compared to the more general and aspirational MDGs, the SDGs try to be all-encompassing. This offers some advantages, like trying to tackle development challenges with a more comprehensive perspective. But it also poses challenges, such as the difficulty of monitoring the systematic impacts of concrete policies across different areas of Agenda 2030.

For example, as we have argued throughout this work, to talk about STs and their possibilities as enablers or inhibitors of different SDGs constitutes a difficult task, not only because of the variety of STs themselves, but also because positive effects on some indicators might inevitably bring about negative effects on others. STs that have positive uses in the context of some SDGs (example: monitoring citizens’ health to contain pandemics; SDG 3) may also have undesirable applications in the context of others (surveillance and social control; SDG 16).

In this respect, we consider that there are at least three SDGs that require special attention: SDG 4 (quality education), SDG 5 (gender equality), and SDG 8 (decent work and economic growth). The main reason for this emphasis is that these three goals are key to building a relation between STs and Agenda 2030 which is mutually enhancing. Paying attention to the positive impacts in these three areas can have significant spill-over effects, whereas not paying attention to the negative effects could cancel out the benefits of potential technological innovations.

Take the example of SDG 4 and SDG 8. Can STs foster education and training to promote inclusion and sustainability? According to the UN, before the COVID-19 crisis, the proportion of children and youth out of primary and secondary school had declined from 26% in 2000 to 17% in 2018. Still, the estimation back then was that 260 million children would be out of school by 2030; that is, 20% of global population in that age group (UN 2021). And yet, already before the pandemic, access and availability of education was not the only problem, as the quality of it was also a concern: around 50% of children and youth lacked basic proficiency standards.

During the COVID-19 pandemic, a majority of schools around the globe closed temporarily, impacting 1.5 billion children (91% of students worldwide). Nearly 700 million were in developing countries. Of course, both rich and poor students are affected by this disruption. However, the consequences in poor places will be far worse. As some studies have shown, the wealth of a country affects exam results as much as the wealth of the pupil’s household: students with the same household income score significantly higher if they live in richer countries (Patel and Sandefur 2020).

The economic impact of the pandemic has forced many to abandon studies in favour of work, plus increased the risk of child marriage, sexual assault and violence at home, teenage pregnancy, and exploitation (The Economist 2020). The Save the Children charity suggests that almost 10 million children may never return to school because of the economic impact of the pandemic (Warren 2021).

In this context, governments, international organisations, and many education institutions, such as universities and private schools, have promoted online or remote models of education. In fact, a wide range of (already existing) apps and online platforms have been further
developed, released freely, or experienced a boom in users after the world had to suddenly stop the young going to school at the beginning of 2020. The World Economic Forum’s Future of Jobs Report (2020) found that between April and June 2020, Coursera, a virtual training platform developed a decade ago by researchers at Stanford University, saw a fourfold increase of people seeking education and training opportunities. The number of employers looking for online training opportunities for their workers increased fivefold, and government online programmes enrolment increased ninefold. These trends show that STs have been essential to advancing in SDG 4 despite the adverse COVID-19 scenario.

Nonetheless, around half of the world’s population (more than 4 billion people) does not have access to the internet. Most of the gap is located in LDCs. In Eritrea, Somalia, Guinea-Bissau, the Central African Republic, Niger, or Madagascar, fewer than 5% are online (Roser et al. 2015). The Internet for All Report (WEF 2016) points out four main reasons for the digital divide: 1) infrastructure, a good fast connection or even electricity is not available; 2) affordability, relating to the cost of devices and connectivity, particularly those below the poverty line; 3) skills, awareness, and cultural acceptance, that is, illiteracy and cultural gender issues; and 4) local adoption and use, referring to online content available in only ten languages. The pandemic is widening the pre-existing gap between how much rich and poor children learn.

Predictions refer to a need for reskilling of about half of the working population in the next five years due to the “double disruption” caused by the pandemic and increasing automation. Although the estimation is that 85 million jobs may be displaced, 97 million are likely to emerge in order to adapt to a new division of labour. We are talking about a redefinition of the job market, not about the massive unemployment wave that some fatalists predict. We should be preparing students for the requirements of this new work environment. Tech skills will naturally be welcomed by employers, but they are not the top skills that will be needed. Critical thinking and problem-solving skills are still the most valued by employers together with emergent skills related to self-management, such as active-learning, resilience, stress tolerance, and flexibility (WEF 2020).

It is feasible to think that tech skills could and should be taken as a means rather than an end, modifying how things are taught and how to make students think in different ways. Teaching computer sciences, for example, is sometimes just incorporating the use of computers and other devices, but it could encompass computer thinking, data analysis, interface design, artificial intelligence (algorithms), and cybersecurity, among others. Besides digital abilities, it is necessary to promote competences like problem solving, creative thinking, and collaboration. Digitalisation, especially internet connectivity, has brought some of us closer but has also widened the gap between others. Without tackling these needs, it is unlikely that the positive impact of STs on other SDGs will reach its full potential.

Take the example of SDG 5 (gender equality). Can STs contribute to gender equality without reproducing structural patterns of violence and exclusion? Whereas there has been important progress on this SDG, such as laws being reformed in several countries to support and advance gender inequality, more girls being educated than ever before, and more female representatives in national parliaments, huge challenges remain. Women aged 25 to 34 are 25% more likely than men to live in extreme poverty; in the workplace, women are paid 16% less than men and hold only 1 in 4 managerial positions. While 39% of employed women are working in agriculture, forestry, and fisheries, only 14% of them appear to be landholders. Such inequalities pose significant challenges in the context of climate change and its impacts given the fact that the climate emergency is more likely to affect those groups that lack access to land and resources (UN 2021).

Can STs contribute to tackling the challenges of gender equality? What are the concrete threats and opportunities? There is no doubt that STs can contribute to women’s participation
in general. For example, social media was key for the organisation of the massive demonstrations of women on 19M (19 March 2020) or the viral spread of women performing and singing “A rapist on your path” all over the world as a protest against gender violence and a sign of solidarity among women of all ages. There have been a number of initiatives of bottom-up organisation, from hashtags to communicate when you board a taxi to local groups of feminist solidarity where women offer and look for services to and for women. In this respect, technology has definitely facilitated processes of economic and political participation that would otherwise be very hard. Digitalisation and STs in general have contributed to raising international attention on the topic.

However, the roots of the problem are much deeper, and technology alone will not solve gender inequalities. The IT industry is itself not free from criticisms. A recent article in a tech industry magazine states that while women make up 47% of the employed adults in the US, they hold only 25% of computing roles as of 2015, despite the fact that science, technology, engineering, and maths (STEM) jobs have grown 79% since 1990 (White 2020). In addition, only 38% of women who majored in computer science are working in the field, compared to 53% of men, and 24% of women with an engineering degree work in engineering compared to 30% of men. IT workplaces are still strongly male-dominated, making it common for women to experience gender discrimination. According to a Pew Research Centre survey in the US (Funk and Parker 2018), this accounts for 50% of women in STEM against only 19% of men.

This has implications for the overall relation between STs and SDGs. Without proper representation of women in the IT industry, it is likely that technological solutions will not reflect their needs and their point of view adequately. STs that are designed from a predominantly male point of view are unlikely to reflect the whole complexity of development problems that are encompassed by Agenda 2030; they will tend to be market-oriented rather than development-oriented. The so-called societal goals (1–6) are just a few examples where women’s perspective becomes vital, but this argument applies to all SDGs.

Moreover, the impacts of the COVID-19 pandemic make clear that the relations between STs, digitalisation, gender, and development are much more complex than expected. On the one hand, STs can help to bridge physical distance, improving the provision of basic services and benefiting women who are often the main person responsible for aspects such as family health and care. On the other hand, the increasing importance of distance work and the home office also poses significant challenges, including the blurring of boundaries between public and private life. Palomar Verea (2021) refers to these situations as “unlocalised virtual realities”: work, social life, school, shows and entertainment, even museum visits or religious and funerary rituals, have suddenly come to the same house as part of the same private realm thanks to videoconferences and virtual sessions, calls, and meetings.

Women have suffered a higher toll from these unlocalised realities. Since they are usually in charge of domestic work and most care-taking activities within families (children, elderly, sick, etc.), this means that women have to deal simultaneously with their own jobs on top of housework and family duties. Thus, although the possibility of remote work might be good news in the context of the COVID-19 pandemic, the resulting overlap between times and spaces may limit women’s productivity and represent risks to their economic security. In Mexico, for example, female employment was equivalent to 45.9% before COVID-19, yet this was reduced to 36.4% from January to April 2020 (UNAM 2020). Future solutions that focus on maximising the benefits of STs while limiting the disproportionate burden that women carry in the context of an extensive home office will require technological innovation, but also more extensive research on gender, law, ethics, and development in general.
And this is not the end of the story. Beyond unequal economic opportunities, lockdown measures, social distancing policies, and 24/7 cohabitation, together with economic and social stress caused by the pandemic, have triggered an increase in gender-based violence. In a few words, many women are being forced to lockdown at home with their abusers. Technology, in particular social media and digital platforms, have played a crucial role in documenting and exposing violence against women. STs have also helped the female population to organise, communicate, and, to a certain extent, protect each other with a number of bottom-up initiatives, before and after confinement.

A remarkable example of the use of digital resources against gender violence is a map of femicides developed by the Mexican geophysicist María Salguero. This is an open access web-based map where Salguero has logged femicides that were registered in Mexico between 2016 and 2020, based on documentation of the National System of Public Security, as well as newspaper notes and reports using geolocation. As Salguero has herself explained, the web map is called “I name you”, to remember the fact that victims are not numbers, but real women, with real stories. It presents geolocated data, which can be filtered through different categories such as age range or murderer–victim relationship, together with a description of how it occurred. The map is also collaborative as one can add new data, including description and place of murder (Loaiza 2020; Mendoza 2020). Apart from publicising the problem of femicides, Salguero’s work has also helped to understand the causes of gender-based violence.

Conclusions

This chapter has explored the interrelations between STs and SDGs, considering both threats and opportunities, costs and benefits. It has been argued that the international development agenda remained oblivious to the digital revolution for a long time. Neither the MDGs nor the SDGs considered adequately the impact of digital and smart technologies on development outcomes. And yet, almost six years after Agenda 2030 was approved, development professionals, academics, consultants, cooperation agencies, and IFIs are gradually starting to become more enthusiastic about technological innovations. The danger is that this sudden swing, from being relatively oblivious to becoming over-optimistic and “back to the future”, is accompanied by the danger of emphasising benefits without closely looking at the negative implications and side-effects of STs.

Given the diversity of STs themselves and the complexity of SDGs, it is difficult to make generalisations. In this respect, although this chapter has sparsely mentioned most of the 17 SDGs, it has mainly focused on a few goals and areas that are illustrative of the complex trade-offs that accompany the application of STs as tools to achieve Agenda 2030. The main lesson is that STs might be significant enablers but are not magic bullets to solve all development problems.

Despite the zeal, it is necessary to keep a cautious approach, balancing between market-oriented and development-oriented devices; taking into account legal and sociocultural conditions locally; and considering the systematic impact of innovations in a broad set of SDGs (not only one or two at a time). Future research should tackle these tensions, contributing to developing STs that are adequate for various local contexts and feeding into the design and implementation of more comprehensive policies. Achieving this might sometimes be possible thanks to local and national resources, but international cooperation and joint technological development might be necessary in other cases.
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